KELLY GORHAM/MONTANA STATE UNIVERSITY

WALL OF WHITE A controlled avalanche at Bridger Bowl in Montana. Scientists hope to solve avalanches' mysteries so they can better predict them.

Studying Snow From the Inside

By JIM ROBBINS

BOZEMAN, Mont. — Not long ago, Ed Adams, a civil engineering professor, studied avalanches by setting them off with dynamite and studying their movement as they buried him, his instruments and his colleagues in a tiny shack.

Recently, though, Dr. Adams, a 58-year-old materials researcher, started a new and somewhat quieter phase of research, studying avalanches in the lab at Montana State University. A $2 million "cold lab" financed primarily by the National Science Foundation and the Murdock Charitable Trust and completed here in November allows Dr. Adams to replicate and control the uncontrollable field conditions of mountains in winter and understand in detail how snow behaves under widely varying conditions. The goal is to be better able to predict an avalanche.

Forecasting avalanches has always been as much an art as a science because of the wide variability of conditions, from time of day and year to type of snow, to slope and temperature.

"Snow seems simple, but it's extraordinarily complex," Dr. Adams said. "If I set a box of snow in the refrigerator and come back in an hour, it's changed significantly. It's almost always in a constant state of motion, and studying it is a moving target." That is where the lab comes in, allowing researchers to vary the sky, sun and temperature to see how snow responds.

There have been 31 fatalities this winter season, 16 in the United States and 15 in Canada, including three snowmobilers in separate avalanches on Saturday in Idaho and Montana. The record in the United States is 35 in the winter of 2001-02. Three of this winter's fatalities occurred within the boundaries of ski trails in commercial skiing areas, which is highly unusual, because of the careful forecasting and control work done in skiing areas.

"The number of fatalities we have had shows they're a difficult phenomenon for us to understand," said Karl Birkeland, an avalanche scientist at the Forest Service's National Avalanche Center here. "There's definitely a need to better understand them."

Montana State is well situated for

Continued on Page 4

JANIE OSBORNE FOR THE NEW YORK TIMES

'COLD LAB' Ed Adams, right, and Andrew Slaughter conduct an experiment.

In 'Cold Lab,' Scientists Study Snow From Inside

From First Science Page

the study of avalanches. There are four Class A avalanche zones — the most severe — at nearby skiing areas, and numerous backcountry locations for study.

For years, Dr. Adams and his colleagues set up their instruments in a small shack on a steep slope at Bridger Bowl, about 15 miles from the university, and sent another researcher up the slope to ignite a two-pound bomb that set off an avalanche.

As the wall of snow rumbled around or over the shack, Dr. Adams, bundled up against the cold, watched his laptop record information on velocity, depth, flow and temperature. He estimates he survived dozens of such self-inflicted avalanches.

In the cold lab, however, where the temperature is 8 degrees below zero, the focus is on a one-square-meter panel, brilliantly lighted by an artificial sun and watched over by an icy artificial sky that can be widely varied to replicate different winter conditions. Wearing his puffy down jacket, wool hat and sunglasses, Dr. Adams shows how he can reproduce the wide range of conditions found on mountain slopes and create different types of snow. "We want to understand what conditions cause the change in the crystalline structure and

Seemingly serene, snow is an ever-moving target for researchers.

the bonding between crystals," he said. It is the missing part of the puzzle of understanding avalanches.

Once he and his students and colleagues have created the snow crystals under certain conditions, they put them under the microscope to see what conditions made for the strongest or weakest layers. Snow layers are the key to predicting avalanches.

The biggest cause of avalanches is a weak layer of snow on a slope covered by solid layers, Dr. Adams said. "The weak layers are faceted crystals, very smooth and unbonded to each other," almost like ball bearings, he said. Strong layers have stronger bonds between crystals, which makes them more stable.

"It's like a layer cake with very weak frosting," Dr. Adams said. When something causes the weak layer, usually less than an inch thick, to give way, the strong layer or layers — there can be dozens, some of them feet thick — go with it. Even skiing at low altitudes can fracture a weak layer and set off an avalanche far above. Contrary to conventional wisdom, sound, unless it is from an explosion, does not set off avalanches.

Some ski areas offer skiers free skiing in exchange for "boot packing" — trampling weak layers with their boots to harden them.

The key to improving forecasting, Dr. Adams said, is understanding the surface layer, where sun and cold cause the snow crystals to change. Understanding the energy transfer on the surface can provide information about what is going on underneath.

As usual, weak layers are the key to this winter's avalanches. "We've had weak layers laid down early in the season," Mr. Birkeland said. "Then a big storm puts a whole lot of load on the weak base."

Heavy, dense snow makes it harder for skiing areas to use ordnance to set off slides for safety reasons; instead the avalanches happen on their own.

Data collected by Dr. Adams in the cold lab on the microscopic level is added to data gained in work setting off avalanches, and to information from weather conditions and from daily snow samples gathered by the ski patrol at the Yellowstone Club, a private skiing area near Yellowstone Park where he is doing research.

Dr. Adams's team plans to combine that data with results from a thermal imaging program developed with Thermal Analytics, a company based in Houghton, Mich. The system, which creates far more detailed data than any previous modeling, is expected to greatly enhance forecasting. It will go into use here in Bozeman in two weeks.

"We have tons of people out in the backcountry" pursuing various forms of recreation, said Mark Staples, a researcher who forecasts conditions for the avalanche center for the Gallatin National Forest and who will use the new program. "There's a lot of variability spatially and temporally. Some days it's safe, and some days less so. But we only have three people forecasting, so the more we can use what Ed's doing, the more we can forecast over a wider area." Right now forecasting is based on field observations and weather forecasts.

Based in the jagged mountains of the northern Rockies, the avalanche center at Montana State was founded by Charles Bradley and John Montagne, veterans of the Army's Tenth Mountain Division who came here after World War II.

Other major avalanche centers include the Swiss Federal Institute for Snow and Avalanche Research in Davos, the world's largest, and the Nagaoka Institute for Snow and Ice Studies in Japan. The University of Calgary and the University of British Columbia have smaller but highly regarded programs.

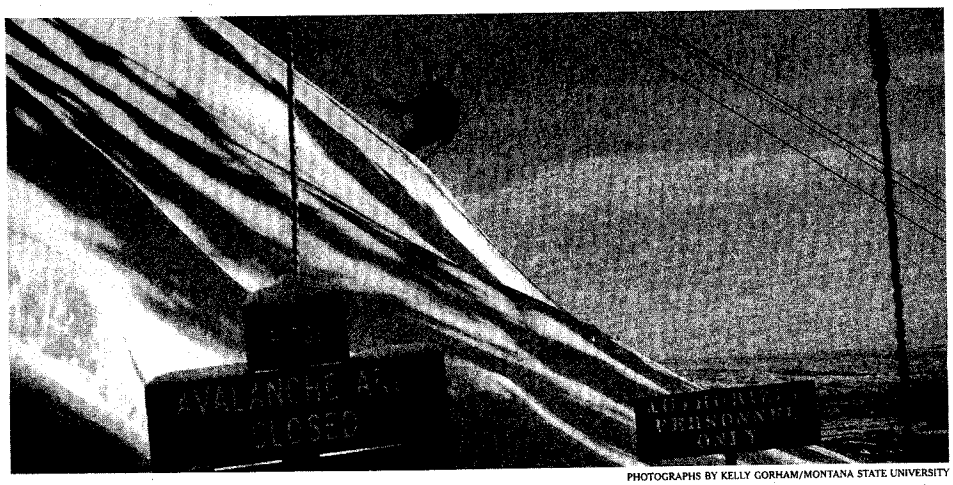
Avalanche prediction has become more important as many more people ski and snowmobile in the backcountry. Until the 1970s, an average of only five people died each year in avalanches in the United States. In the 1990s, with more skiers and snowmobilers on the slopes, the average increased to 20. In the last decade, the deaths have averaged 28 a year, but experts say the deaths have not increased as quickly as the number of backcountry users.

The jury is still out on the best way to survive an avalanche. Some researchers say the most critical thing is to create a pocket in front of the face to breathe while waiting for rescue. "I would swim, though," Dr. Adams said. "Get prone in the snow and stay on top." A new product called an avalanche balloon system is carried by some skiers. If they get caught in an avalanche, they can pull a ripcord that inflates balloons and is said to keep them afloat on the surface of the snow.

Dr. Adams traces his zeal to understand avalanches to his days as a bartender and ski bum at Alta, a ski resort in Utah. "The lodge I was working in got hit by an avalanche," he said, "and it took a whole wing out and blew cars from the parking lot across the road. It was impressive."

Avalanche stories often have much worse endings. Eight snowmobilers were killed in an accident in British Columbia in December. In 2003 in British Columbia just north of Glacier National Park, 17 teenage cross-country skiers were buried as they skied across a meadow; 10 survived. Tragedy has struck the researchers as well. One of Dr. Adams's former graduate students, Blake Morstad, was killed in a slide while skiing in Idaho's backcountry. A documentary, "The Last Dozen Turns," recounts the story.

Despite the danger of avalanches, Dr. Adams says he may one day return to doing research from the inside of an avalanche. "I'd like to go back," he said. "But for me understanding the metamorphosis of snow in the cold lab is every bit as interesting."



PHOTOGRAPHS BY KELLY GORHAM/MONTANA STATE UNIVERSITY

GOING UP A ski patroller riding a lift used to reach an area for avalanche control operations at Bridger Bowl.

HEAT Ed Adams, right, capturing thermal images with a student, Pat Staron.

A TEST Dr. Adams and Robb Larson, a researcher, with a crash dummy.